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(19)

(54) IMPROVEMENTS IN OR RELATING TO METHODS OF AND APPARATUS FOR REPRODUCING PICTURES

(71) We, DR.-ING. RUDOLF HELL, G.m.b.H., a German Body Corporate, of 1—5 Grenzstrasse, 2300 Kiel, Germany, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The present invention relates to a method of and apparatus for reproducing pictures, such as screened colour separations for multi-colour printing, from original or master pictures, such as continuous tone pictures, in colour or in monochrome.

In the art of picture copying and print production it is known that, for the structure of a printing or reproduction raster to be as invisible as possible to an observer, with block and white pictures the raster networks are displaced at an angle to the horizontal. In order to produce multi-coloured pictures, the raster networks of the colour separations must additionally be mutually angularly displaced in order to avoid the appearance of Moire patterns and colour deviation.

Such an angular displacement of the raster represents no problem when using flat bed engraving machines, for in this case it is a simple matter to rotate the picture original and recording carrier with respect to the raster. The recording member may be an engraving needle, recording glow lamp or the like.

It is, however, difficult to achieve a true angular displacement of the raster when using orthogonally-oriented machines, such as drum scanners and electronic type-setting machines. Diagonal mounting of the picture original and the recording carrier, for example, on the drums of a drum scanner cannot be considered for a variety of reasons. The most significant reason in this case is that the advance and peripheral speed of the drums must be altered for each angular displacement of a raster. The smallest deviation from the optimum would lead to intolerable Moiré pattern formation. So far as drum engraving machines are concerned, proposals have already been made involving considerable displacement of the raster dots from line to line and by suitable selection of their spacings. However, with these rasters, which in point of fact only simulate angular displacement of the raster, a certain amount of Moiré patterning has occurred always in the reproduction.

It has also been proposed to scan a drawn raster pattern at the same time as the picture original is scanned, thus obtaining signals representing the raster pattern which are superimposed on the picture signals. This raster pattern can, in fact, be used in the required inclined position. The disadvantage in this case, however, is that an additional scanning head and a longer or additional drum are required. The amount of equipment required is thus considerably greater. Moreover, the displacement is not real but only imitated.

The possibility of obtaining genuine angular displacement of the raster is now offered by digital techniques. In one proposed method of setting half-tone raster pictures with the aid of photo-type setting machines, the tonal values between white and black can be laid out in an endless number of stages or numbered in accordance with a tonal value scale. One elemental raster area is allocated to each tonal value, which contains a black dot of varying size, hereinafter referred to as a spot. The size of this spot determines the tonal value which represents the elemental raster area at the position of the picture area to which it belongs. White and extremely light parts of the picture are shown by small spots, dark or black by large spots which may almost entirely cover the surface of the elemental raster area. Elemental raster areas with the dark spots can be regarded, in accordance with the aforementioned photo-type setting method, as small pictures, for the re-recording of which in accordance with

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corresponding originals, electronic recording data are produced and lead into a memory.

Among experts in the field of the graphic arts, elemental raster areas with these spots contained therein, are called "raster dots" irrespective of their size. In order to avoid misunderstandings, this expression is avoided in the present specification and the expressions "spot" or "raster spot" only are used.

The recording data of the raster spot are recalled from the memory by means of the picture signals obtained during scanning of the original, for recording of the raster picture. The picture signals control either the simultaneously occurring recording or they are themselves stored for later use.

This known method is, however, not suitable for solving the problem with which the invention is concerned, since, if the raster structure is not oriented at right angles and, therefore, is at an angle to the horizontal of the field of vision of the observer, or if a plurality of raster structures is to be printed one above the other, which, moreover, still have to be respectively rotated, no raster is produced having a structure oriented at right angles which can be recorded by means of the machines in question.

It is thus on object of the invention to cover the picture original with one or more raster networks, the meshes and angles of inclination of which are so dimensioned that large meshes having a congruent network structure, hereinafter referred to as "parcels", are obtained. These parcels form a new superimposed network oriented at right angles.

The invention thus consists in a method of reproducing pictures in which raster subareas having covering spots are formed in accordance with a tonal valve scale, the sizes of which spots correspond to the tonal values of said scale, wherein electronic recording data are determined for said subareas and stored, wherein picture signals are obtained by electro-optically scanning a picture original, which signals recall the appropriate stored recording data for recording of the picture original, and wherein one or more raster networks are allocated to the picture, the meshes and angles of inclination of which networks are so dimensioned that orthogonally-oriented parcels of congruent net structure are established, which parcels are split up by division into smaller orthogonally-oriented said sub-areas, at least one of said raster networks being not orthogonally-oriented.

Advantageously, originals in correct scale are produced for each raster network and for each tonal value with equal and uniformly arranged covering spots, the stored electronic recording data being determined therefrom.

Preferably one raster network is orthogonally-oriented.

In a preferred embodiment of the invention, the parcels each consist of a three by three array of square meshes of an orthogonally-oriented raster network; the lines of one further raster network intersect the corner points and centres of the side lines of the parcels, and are inclined at 45°, the lines of two further raster networks are inclined by $+\arctan \frac{1}{3}$ and $-\arctan \frac{1}{3}$, and intersect each corner point and side of the parcels at points $\frac{1}{3}$ and $\frac{2}{3}$ along their length.

A single raster network which is not orthogonally-oriented is advantageously provided for reproducing monochromatic pictures.

Further features of embodiments of the invention consist in that the parcels may be divided into columns and that the sub-areas are obtained by transverse sub-division of the columns. Thus, it is advantageous to undertake the splitting up of the parcels into sub-areas of equal size.

In one particular embodiment, the splitting up of the parcels into columns and sub-areas, is undertaken by means of an orthogonally-oriented raster network.

Conveniently the stored recording data are determined with the aid of an orthogonally orientated optical-electronic raster scanner, each sub area being sequentially line scanned, the recording data for each line comprising a sequence of white or black spot units.

In dividing the parcels into sub-areas, it is particularly advantageous to undertake the splitting up in such a manner that as many sub-areas as possible are obtained with the same or symmetrical spots, so that it is necessary to store only once the recording data of the same or symmetrical sub-areas having different positions within the parcel under one address, these recording data of the symmetrical sub-areas being transferred before recording into an operation register and from there are released for recording in a reciprocal sequence by means of an electronic control system.

The present invention is not limited to the cross raster used preferably in the reproduction art but extends to raster networks, the meshes of which are non-square rectangles, for example triangles, rhombi, hexagons and so on. The expression "cross raster" means a raster having a square mesh structure. Such raster structures can be combined in any manner.

The invention also consists in apparatus for carrying out the method.

In order that the invention may be more clearly understood, reference will now be made to the accompanying drawings which illustrate certain embodiments thereof by way of example, and in which:—

Fig. 1 shows two orthogonally-oriented parcels composed from a non-orthogonal

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raster network with homogeneous tonal value,

Fig. 2 shows a parcel formed from four superposed raster networks,

Figs. 3*a* to 3*c* show portions of the individual raster networks from Fig. 2 of parcel size with equal and uniformly divided covering spots,

Fig. 4 shows a portion of the raster network of parcel size according to Fig. 3*c* with different spots representing large tonal values,

Fig. 5*a* shows a portion of a raster network of parcel size as in Fig. 3*c* but with finer longitudinal and transverse division,

Fig. 5*b* shows a portion of a raster network of parcel size with hexagonal meshes and triangular spot shapes,

Fig. 6 shows an example for electronically recording two raster sub-areas with covering spot members from the parcel according to Fig. 5*a*, and

Fig. 7 shows one embodiment of apparatus for carrying out the method of the present invention.

In the drawings, like reference numerals refer to like elements.

Referring now to the drawings, Fig. 1 shows a raster network which consists of lines 1 and 2. Mesh fields 3 are formed by the intersecting lines 1 and 2 in which black spots 4 are contained. The size of the spot represents the tonal value which the image area is to have at the point which belongs to the corresponding mesh. The spots are all chosen to be the same size and have the same shape since they are all to belong to an image area with an homogeneous tonal value.

The raster network 1/2 is not orthogonally-oriented. It should be understood by this expression that the lines of the network are rotated with respect to the horizontal reference line of the image area of the observer. The rotation or angular displacement of the raster network is necessary when reproducing a monochromatic picture in order to convey a better picture impression to the observer. The optimum value of the angle of rotation of the raster network and also the size of the meshes are not accurately determined. Intersection points of the network lines 1 and 2 can be intersection points of a large mesh orthogonal network, at the same time. These points 5, 6, 7 and 8, or 6, 7, 9 and 10, which are joined by a dotted line represent such mesh squares, hereinafter referred to as "parcels". It will be apparent that even in the orthogonal axial direction equal parcels join up with congruent portions of the raster network formed from lines 1 and 2 and cover the entire image field.

These individual parcels contain several complete meshes 3 with undamaged spots 4. Several meshes, however, and also spots, are divided up by the boundary lines of the parcels. A geometrical balance results in that the total area of the meshes in each parcel make up whole meshes, so that, therefore, the content of the parcel corresponds to a whole number of meshes. The upper complete parcel in Fig. 1 consists of five complete meshes with undamaged spots and 16 mesh parts having at most portions of spots, which together make up 8 complete meshes. The parcel thus embraces altogether 13 meshes.

This individual non-orthogonally-oriented raster network 1/2 is used preferably for monochromatic image reproduction. In the reproduction of polychromatic pictures, as is known, the individual colour separations are printed by mutually angularly displaced or rotated raster networks. As Fig. 2 shows, the above-described principle of varying the mesh size and angle of inclination, can also be used advantageously for multi-colour printing. Fig. 2 shows a surface member having four mutually rotated superimposed raster networks which are formed from lines 11/12, 13/14, 15/16 and 17/18. Each mesh of the divided network is shown hatched. The raster measurement and thus the size of the meshes of the individual network is so dimensioned and the angle of rotation so selected that a square parcel defined by the corner point 19, 20, 21 and 22 is obtained. The network 11/12 is orthogonally-oriented. It is usual in multi-colour printing to select one of the raster networks, preferably the one for the yellow colour to have an orthogonally-oriented structure. The network 11/12, as is apparent from the drawing, also provides the sizes of the parcel which consists of 3×3, i.e. 9 meshes.

The raster network 13/14 shown by dotted lines is positioned at 45° to the orthogonal axis. It is formed by diagonals which extend through the corner points 19, 20, 21 and 22 of the parcel square and through the lines extending parallel thereto which intersect the sides of the square in the centres, namely at points 23, 24, 25 and 26.

The network 15/16 is inclined at an angle of arc tan $\frac{1}{3}$=approximately 18.3°. Also in this case the lines of the network (shown broken), extend through the corner points of the parcel and intersect the side lines at $\frac{1}{3}$ or $\frac{2}{3}$ of their length. The network 17/18 has the same structure as the network 15/16, but is positioned mirror symmetrically thereto, thus its network lines extend through the corner points of the square 19—20—21—22 and intersect its side lines at $\frac{1}{3}$ and $\frac{2}{3}$. The lines of this raster network are characterised by —x—x—.

One can imagine the combined network system represented extending as far as de-

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sired in both the horizontal and vertical directions. In all cases, equal-sized parcels are conjoined with congruent network structures in a row and cover the entire image area.

In addition to the example of Fig. 2 there are further possibilities of designing parcels having a congruent network structure. For example, four meshes of an orthogonally-oriented raster network of one colour could be provided as the smallest parcel. Larger parcels are also possible, for example $4\times4=16$ meshes.

In all cases, however, they are as large as are suitable on the whole for re-recording. The parcels are divided up into smaller sub-areas and recorded; they should be approximately the same size as the meshes of the raster network. In practice, the following values are usual. A mesh of the orthogonally-oriented network 11/12 with a resolution of 50 lines per cm., should have a side length of 0.2 mm. A mesh of the network 13/14 may have a side length of 0.225 mm and should thus correspond to the raster 44.5 lines per cm. The meshes of the networks 15/16 and 17/18, should have side lengths of 0.18 mm and thus correspond to a resolution of 55.5 lines per cm. The meshes of the network 11/12, 0.2 mm in side lengths furnish a nominal scale and can be considered as of average size. In this example, the parcel is split up into equal-sized sub-areas which will be referred to hereinafter as raster sub-areas.

The tonal value information of the picture is, as we know, given by means of the covering value, i.e. by means of the size of the spot and, on a smaller scale, also by the shape of the spot within the raster sub-areas which are allocated to the parts of the image to be represented. Should the picture resolution be, for example, 50 lines per cm., then 9 raster sub-areas are required to represent the tonal value of a parcel. The division of the parcel into raster sub-areas thus corresponds to the raster network 11/12, i.e. the raster sub-areas are equal to the meshes of this raster network. It must be emphasized, however, that this division is a simple exception. Much more complicated cases may occur which have to be taken into consideration, as will be shown later on.

Fig. 3*a* shows a parcel covered with covering spots of a predetermined tonal value of the raster network 11/12. The spots 4, in this case selected to be square, are positioned in the centre of the meshes 3 which simultaneously represent the raster sub-areas Ia, IIa, . . . IIIc. An homogeneous tonal value may be adopted for all the parcels so that all spots 4 are equal in size. The surface covering which is the total of all the spot areas with respect to the parcel surface, determines the tonal value of the allocated part of the picture. In the example, it may have the numerical value 20%.

Fig. 3*b* shows approximately the same covering value. The distribution of spots in this case is in accordance with the raster network 13/14, the meshes 3 of which, shown by dotted lines, do not cover the side lines of the raster sub-areas. The covering spots 4, which are centrally positioned in the meshes are distributed non-uniformly over the parcel, as is clearly visible.

Similar ratios are obtained for the meshes of the network 15/16 and 17/18. The network lines 15/16 shown by dotted lines in Fig. 3*c* extend at appropriately differently inclined angles through the image area. The distribution of spots is shown with an approximately equal tonal value of 20%. The raster network 17/18 would be a mirror image of Fig. 3*c* and is, therefore, intentionally not shown.

It may be agreed that scanning and recording of the picture to be reproduced from below upwardly is effected in picture lines which are arranged adjacent one another from left to right. The columns I, II and III of the parcels are then portions of three adjacent image lines. During reproduction of the parcels, thus, firstly the raster sub-areas Ia, Ib and Ic are recorded which form the first column of the parcel and belong to the first image line. The columns of sub-areas IIa, IIb, IIc and IIIa, IIIb, IIIc follow after relatively large intervals, namely after recording of the complete image line or in roll machines, after each complete rotation of the roll. The parcel is thus concerned with three image lines.

Furthermore, it is assumed that the parcel will belong to one point of the picture with an homogeneous tonal value. Thus, all the spots are the same size and same shape. The spots may take diverse shapes, e.g. circles, elipses, rectangles or squares, as shown in the example. They should, however, even when they represent extremely large covering values, not exceed the boundary line of the meshes.

In Fig. 3*c*, which represents one parcel of the raster network with the lines 15/16, it is apparent that the dividing line which splits the parcel square into 9 areas, intersects the spots divided over the total area completely non-uniformly. The raster sub-areas Ia to IIIc are obtained by longitudinal and transverse division of this parcel. The covering area corresponding to the tonal value of the parcel consists of the total of spots and part spots within the raster sub-areas. One parcel which represents a predetermined tonal value consists of 9 raster sub-areas. Thus, with 64 tonal value steps, 576 raster sub-areas are required. For all of them electronic recording data must be

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obtained and stored. The raster network 17/18 which is symmetrical with the network 15/16 necessitates also the same number of raster sub-areas.

The raster network formed from lines 11/12 makes an exception in the dimensioning example according to Fig. 3*a*; the network meshes and raster sub-areas are identical and all raster sub-areas belonging to one parcel are the same. This makes it possible to store the recording data only once for each raster sub-area so that relatively little storage space is required.

The structure of the raster network 13/14 shown in Fig. 3*b* for which the raster sub-areas Ia . . . IIIc are again recorded at approximately equal tonal value, is symmetrical. The raster sub-areas Ia, Ic, IIIa and IIIc are symmetrical with respect to the horizontal and vertical axis, likewise the raster sub-areas Ib, IIa, IIIb and IIc. In this case, it is also possible to save a large amount of storage space. It is sufficient actually to store the recording data of the raster sub-areas only once. All possible symmetrically equal raster sub-areas can be recorded by controlling the deflection of the electron beam to be recorded with the aid of inverted control data from one deflecting direction or both. This can be brought about by means of electronic control equipment which is connected between the core store and the deflection electronic.

The reproduction is controlled by picture signals which are obtained when scanning the picture original in that analogue scanning supplies measurement values from which values are derived by timing pulses at equal intervals and are numbered according to a tonal value scale. These numbers represent the picture signals as long rows of binary coded numbers. The frequency of the timing pulse is obtained from the drive system of the reproducing equipment and is so selected that it agrees with the frequency at which the sub-areas are recorded. Thus, after recording one of the sub-areas, the recording data is available for the next.

First of all, the recording cycle will be described with the aid of Fig. 3*c*, but without making use of the above-mentioned means for saving storage space. At zero time, the recording member, e.g. a light spot projected by a cathode ray tube onto the recording plane on the path I in the direction of arrow 27, passes over the lower boundary line of the sub-area Ia. By means of the picture signals recalled from the storage means, the recording data of the raster sub-area Ia are ready and control the recording. The special technique of this recording will be referred to in more detail hereinafter.

At the beginning of recording the raster sub-area Ib, the new recording data are available therefor. The tonal value should firstly be the same as that of the raster sub-area Ia, since the part of the image to be recorded should have homogeneous toning. Thus, the same store address is again recalled. An internal counter raises the address by a small amount. Thus, in the store means, a store cell, adjacent that last used, is actuated which contains the data for recording the raster sub-area Ib. At the beginning of recording the raster sub-area Ic, furthermore the new recording data are available. The tonal value may be the same in this case too. Adding a further small amount, the address is again raised and, furthermore, the adjacent store cell is operated.

During recording, the recording member passes over the upper limit of the raster sub-area Ic and thus the limit of the parcel. It joins up with a congruent parcel which, since furthermore equal tonal value is adopted, also has equal covering spots. The triple ring counter reverts to the starting position. $Ia^1 = Ia$ is thus recorded. On further operation, the recording of the raster sub-area Ia, Ib, Ic, Ia^1, Ib^1 . . . is repeated as long as the tonal value remains constant.

After changing the lines or revolution of the roller, further transporting of the recording member is effected by the width of a raster sub-area. On path II, the recording member reaches the lower boundary of the area IIa. The same tonal value should still be present and, therefore, the same store starting address is applicable as before.

By horizontal transporting of the recording member, however, a second triple ring counter is coupled in which, after each step, increases the store address by the numerical value of three store cells. Thus, that store cell is operated which contains the data from raster sub-area IIa. The recording of sub-areas IIb and IIc, IIa^1 and IIb^1 and so on now follows on in known manner. After further horizontal transport logically the raster sub-areas IIIa, IIIb, IIIc, $IIIa^1$ and so on are recorded. Finally, the recording of an additional congruent parcel begins which, with the same tonal value, consists of the same raster sub-areas Ia, Ib . . . IIIc.

In Fig. 4, the parcel is again, as in Fig. 3, divided into three columns each having three raster sub-areas. The parcel may no longer remain, however, at a picture point having an homogeneous tonal value but, within the parcel two areas of different tonal value meet. The transition zone between these two areas, which is shown by lines 28 and 29, extends transversely of the parcel. Below the line 28 is an homogeneous area with light tonal value, e.g. 20%, above the line 29 is a similarly homogeneous but darker area, with high tonal value, e.g. 60%.

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The transition between these different tonal areas should not be zero even with very strong picture contrast. Thus, the transition zone defined by the lines 28 and 29 which may, in practice, be approximately 0.1 mm wide, is covered by tonal values which increase from 20 to 60%.

Upon reaching the lower boundary line of the parcel, the recording data from the tonal values step 20% of the raster sub-area Ia are ready. Upon continuing, the raster sub-area Ib is reached. The tonal value 30% is established by the scanning. A new store block is thus operated which contains the recording data of the parcel of tonal value 30%. In order to recall the recording data of the raster sub-area Ib, a counting unit is added according to the above-detailed description having regard to the initial address. The same occurs now with the new address so that also, in this case, the second store cell of the newly-operated store block is immediately called up for recording the raster sub-areas. At the end of the recording of the raster sub-area Ib, the number of the tonal value is available for the raster sub-area Ic, in this case 60%. The store block for the tonel value 60% is addressed and, in accordance with the automatic address rating, the third cell of this block is recalled for recording the raster sub-area Ic.

In recording subsequent picture lines, the raster sub-areas of the second column IIa, IIb to IIIc are recorded in a manner already known. The tonal values in accordance with the sample of Fig. 4 are determined at 20% for IIa, 40% for IIb and 60% for IIc and furthermore the tonal value 20% for IIIa, 50% for IIIb and 60% for IIIc in accordance with the position of the centre of the raster sub-areas on the picture.

The spots which are frequently composed of a plurality of of spot portions assume numerous shapes. Seen from a greater distance, the contrast threshold is clearly apparent which passes transversely through the parcel and is divided into an upper dark area, and a lower lighter area. The desired shapes of the spots of the raster elements are no longer perceptible in reproduction due to their small size. The eye distinguishes a clear separating line between the two differently toned picture areas.

The invention offers, however, additional possibilities only hinted at up to now. Fig. 5*a*, for example, shows that the parcel can be divided by more precise longitudinal divisions into even smaller columns, for example I, II . . . IV and the columns by a plurality of transverse lines into smaller raster sub-areas, e.g. *a* to *f*; on the whole in this manner more raster sub-areas are obtained than, for example, with the divisions shown in Fig. 2. The storage space required for the recording data is indeed larger with respect to the hitherto used parcel divisions, but in this case equal and symmetrical raster sub-areas occur whereby the surplus demand is restricted. Fig. 5*b* shows a comparable circumstance, the raster network here comprising hexagonal meshes and triangular spot shapes.

All the recording data for one parcel are arranged in the store means in direct succession in the sequence Ia, Ib, Ic, IIa and so on. One can, however, regard the recording data of a whole column as a unit and undertake transverse division of the column, as necessary, into sub-areas of different size. With image parts of homogeneous tonal value for example, the whole column is recorded undivided. Image parts abounding in contours on the contrary, having greatly alternating tonal values, necessitate division of the columns into more and smaller sub-areas which can be of different sizes. In this manner, the tonal values are recorded in a more precise manner and conform closer to the original. The freqency of the timing which is required for this operation must be so great that it corresponds to the scanning of the smallest sub-area which may arise through a column division. It is achieved by electronic methods that timing pulses only become effective if changes in tonal value of a predetermined minimum size occur, for only then is it necessary to recall the address of a new parcel having another tonal value. The division of the column could be continued for such time until finally for each recording line, a sub-area is recalled and corresponding to each picture line, the address of the parcel of the established tonal value. This extreme measurement necessitates, however, extremely high timing frequencies and stores having very small cycling times, since reproduction with fast operating machines should be effected in as short a time as possible. According to experience, it is sufficient if, after a plurality of recording lines, for example four, the new tonal value is established and, if necessary, corrected.

It is to be noted that more recording data of the parcels has to be stored if the columns are composed of sub-areas of different sizes. It is, in this event, for example, no longer possible to save storage space, because small symmetrical sub-areas no longer exist. The recording data are generally used for direct time equal reproduction of the raster separations. However, they can themselves also be electronically stored, for example on magnetic tape, in order to be able to control the picture recording at a later time. This method, however, offers the advantage of enabling scale changes between original and reproduction, if the timing frequencies and the recording speeds can be changed or, if

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for example, drums of different diameter are used.

The particular picture recording is effected by means of a cathode ray tube. Whilst a recording carrier is moving at constant speed, e.g. in drum equipment from above downwardly, a cathode ray tube projects a light spot moving very rapidly always from left to right onto the light-sensitive carrier. The amplitude of the point movement is equal to a column width and thus also equal to the width of the raster sub-areas. By means of horizontal light spot movement, recording lines are produced on the recording carrier which, by means of the vertical movement of the recording carrier, generate a described column surface. The light point can, however, by controlling the electron beam, be light and dark scanned. In this manner hatched figures are obtained, namely the spots.

In Fig. 6 the raster sub-areas Ia and Ib of the parcel division are shown enlarged with their covering spot in accordance with Fig. 5*a*. In the left hand bottom corner of the raster sub-area Ia, a smaller circle 30 is shown, the diameter of which is equal to that of the light point of the electron beam to be recorded. The sub-area Ia consists of eight horizontally superposed recording lines which each consist of 12 units of point diameters. The whole raster sub-area thus consists of 96 spot units.

Part of the square spot 31 belongs to the raster sub-area Ia. With the aid of the electron beams, this partial spot should be recorded as accurately as possible. It is to be noted that the aforementioned hatching should be effected automatically, and only the light-dark control of the recording light spot takes place by means of the stored data. Thus, during the photographic process, reversal of the tonal values occurs so that light scanning of the electron beam causes blackening of the film.

The first four recording lines remain dark during recording of all their 12 time units. The fifth recording line is characterised by the data: 6× light, 1× dark, 5× light. The line 6 consists of: 4× light, 4× dark, 4× light; the line 7 of 2× light, 6× dark, 4× light and the last recording line 8 finally consists of 1× light, 8× dark, 3× light. All these data are in an electronic register at the beginning of the recording of the raster sub-area Ia, which will be described in more detail hereinafter.

Recording of the raster sub-area Ib follows on directly after recording of the raster sub-area Ia. The recording data have already been recalled from the store, transferred into the electronic register and control the light-dark scanning of the electron beam during recording. The raster sub-area Ib contains the remainder of the covering spot. Since both the portions are joined together in a row without joins, the spot is complete.

The steep edges of the spot 31 experience distortions during recording. The actually recorded shape of the spot is the surface 32 shown hatched. Its boundary line 33 twists like a wavy line about the sides of the spot. The recorded surface 32 is, however, equal to the surface of the spot 31. The boundaries of the outer inwardly-curved corners of the boundary lines 33 are effected by the circular shape of the recording spot. The roundness on the inner outwardly curved corners is effected by below threshold pre-exposure and halation of adjacent spots.

Fig. 7 shows apparatus for carrying out the method of the invention. The arrangement comprises a drive motor 34 which drives a shaft 35 so that drums 36 and 37 mounted thereon rotate in synchronism A picture original (master) 38 is secured to the drum 36, and a sheet of light-sensitive material 39 is secured to the drum 37. A scanning lens 40 scans the original 38 impinging thereon at point 41, and supplies electric voltage signals to a conductor 42, the amplitudes of which signals correspond to the tonal values at the image point 41. After passing through several electronic units, the method of operation of which will be explained later, the signals reach a cathode ray tube 43 in the form of control data and control the brightness of a light spot generated by the electron beam on the screen thereof. This light spot is projected with the aid of a lens 44 onto the light-sensitive material 39, and, in accordance with the control data, records a reproduction of the original at point 45.

After each rotation of the drums, an advance movement of about the amount of a column width is effected. This advance is necessary so that, during reproduction of a picture original, the entire image area is dealt with.

The signals supplied via the conductor 42 are fed to a unit 46 to which timing pulses are continuously fed over a conductor 48 from the timing mechanism 47. The timing or pulse frequency is of such size that, with the existing peripheral speed of the drums, the timing intervals correspond to the height of the raster sub-areas or to a multiple of the recording lines. Each timing pulse on the unit 46 determines the signal voltage directly applied to the conductor 42, it is assigned a tonal value step and passes the numerical value of this step as a binary coded number via a cable 49 to an electronic address register 50. This number is the initial address of the space in the store means which contains the data for recording all the raster sub-areas, of which the parcels with the established tonal value consists.

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The parcel is, however, divided into a plurality of columns, for example I, II and III corresponding to Fig. 3*c*, and each column is divided, furthermore, into a plurality of raster sub-areas *a*, *b* and *c*. Each of the raster sub-areas contains spots which correspond to the covering value of the allocated tonal value. The data of each individual raster sub-area of each parcel can be addressed in the following manner in the store means. The number of the recalled tonal value step is registered as a binary number in the address register 50. However, the latter is still connected by the conductors 51 and 52, to the ring counters 53 and 54. An adding device in the address register adds the numbers passed via the conductors 51 and 52 to the stored tonal value number. The counter 53 counts in succession the raster sub-areas Ia, Ib and Ic of the first column and passes the values 0, 1 and 2 to the address register 50 via column 51. After transition into the zero position, recording of the first raster sub-area Ia of the same column of the parcel following in the recording direction is commenced. The further raster sub-areas Ib and Ic follow on by further counting of the counter 53 in position 1 or 2. The cycle continues logically until the entire image line is recorded. It consists of equal columns of all parcels positioned one behind another in the recording direction.

The counter 54 is in the zero position during recording of the entire picture line formed from the first column. Before commencing recording of the next image line or before commencing the next rotation of the drum, an advance is effected on the scanning and recording side by one picture line width or one column width. By means of the advance, a pulse is generated which advances the column counter 54 by one unit over a conductor 56. This unit is a number which corresponds to the address difference of the data group which makes use of one column of a parcel.

Recording of the second image line follows, all the second columns i.e. IIa, IIb and IIc of all successive parcels being recorded one after another until after a further advance of the counter 54, before beginning the third picture line, the third columns are recorded. The process continues logically until reproduction is terminated.

One raster sub-area is used as a recording unit. In order to record such a raster sub-area at a predetermined tonal value, the initial address of the store range is recalled by the picture signals which contains the recording data of the parcel to which the raster sub-area belongs. The recalling of the initial address is effected over the conductor 49. The counters 53 and 54 increase this initial address in the address register 50 until the data of the raster sub-areas are recalled by the correct position within the parcel and recorded.

This method of procedure remains the same even when smaller sub-areas are recorded individually or in groups. By means of the timing at the input of the counter 53, the frequency of which is higher due to the finer division, it is ensured that when recording a column, the data of the recording line control the electron beam position within the parcel.

The sub-area according to Fig. 6 consists of 8 recording lines. Consequently, the frequency of the horizontal deflection of the electron beam which is to be undertaken by the deflection amplifier 57 over the conductor 55 must be measured. A timing pulse at a frequency eight times higher than the recording rate, which is fed over a conductor 58, synchronises the deflection amplifier 57. During deflection, i.e. during the recording time of a horizontal recording line, the beam is constant. The flyback time is small as compared with the recording time.

With drum generators, the beam does not need to be deflected in the vertical direction, since relative vertical movement is achieved by movement of the drum. In all electronic photo-type setters, vertical control of the electron beam is necessary, since the recording carrier is not moved during recording. All other functional features concur with those shown in Fig. 7. Therefore, there is no representation in the drawings of a specific embodiment using an electronic photo-type setting apparatus.

During horizontal deflection, the electron beam is light or dark scanned. The register 59 supplies the voltage for this scanning. Also in this case, a firm connection to the timer is effected over a conductor 60. If a recording line consists of 12 spot units, then a timing pulse must be fed to the register whose frequency is 12 times greater than the timing pulse on the conductor 58. In practice, the frequency of the timing pulse on the conductor 60 is actually a little higher, e.g. 14 times higher, because the flyback time after horizontal deflection cannot be completely disregarded.

The register 59 is a so-called shift register and is effective as an intermediate store between the data store 62 and the recording tube 43. The shift register 59 contains additional electronic means for releasing the stored data for light or dark control of the electron beam in accordance with subsequent programmes. By inverting the sequence of the data for the horizontal recording lines, or inverting the sequence of the recording lines, or by inverting both, it is achieved that all four mirror-symmetrical pictures of a raster member can be represented.

It should be observed that altering the

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scale between reproduction and original is easily possible by altering the drum diameter. However, in order to avoid image distortion, the horizontal movement of the advance on the recording cycle is so controlled that the picture proportions remain the same.

WHAT WE CLAIM IS:—

1. A method of reproducing pictures in which raster sub-areas having covering spots are formed in accordance with a tonal value scale, the sizes of which spots correspond to the tonal values of said scale, wherein electronic recording data are determined for said sub-areas and stored, wherein picture signals are obtained by electro-optically scanning a picture original, which signals recall the appropriate stored recording data for recording of the picture original, and wherein one or more raster networks are allocated to the picture, the meshes and angles of inclination of which networks are so dimensioned that orthogonally-oriented parcels of congruent net structure are established, which parcels are split up by division into smaller orthogonally-oriented said sub-areas, at least one of said raster networks being not orthogonally-oriented.

2. A method according to claim 1, wherein originals in correct scale are produced for each raster network and for each tonal value with equal and uniformly arranged covering spots, the stored electronic recording data being determined therefrom.

3. A method according to claim 1, wherein, when a plurality of raster networks is allocated to the picture, one raster network is orthogonally-oriented.

4. A method according to claim 1, 2 or 3, wherein the parcels each consist of a three by three array of square meshes of an orthogonally-oriented raster network, the lines of a raster network inclined at 45° intersecting the corner points and the centres of the side lines of said parcels, and the lines of two further raster networks inclined at $+\arctan \frac{1}{3}$ and $-\arctan \frac{1}{3}$ intersecting the corner points and the sides of each said parcel square at points $\frac{1}{3}$ and $\frac{2}{3}$ along their length.

5. A method of reproducing monochromatic pictures, according to claim 1 or 2, wherein there is provided only one raster network, this raster network being not orthogonally-oriented.

6. A method according to any one of claims 1 to 5, wherein the meshes of the raster network or networks are rectangular.

7. A method according to claim 6, wherein said meshes are square.

8. A method according to any one of claims 1 to 5, wherein the raster networks are combined square and non-square structures.

9. A method according to any one of claims 1 to 8, wherein the parcels are divided into columns and said sub-areas are obtained by transverse sub-division of said columns.

10. A method according to claim 9, wherein said sub-areas are of equal size and are obtained by sub-dividing said columns.

11. A method according to claim 9 or 10, wherein the parcels are divided into columns and said sub-areas by means of an orthogonally-oriented raster network.

12. A method according to claim 2 or any claim appendent thereto, wherein the stored data are determined with the aid of an orthogonally oriented optical-electronic raster scanner, each sub-area being sequentially line scanned, the recording data for each line comprising a sequence of white or black spot units.

13. A method according to any one of claims 1 to 12, wherein the parcels are split up in such a manner that as many sub-areas as possible are obtained with equal or symmetrical spots.

14. A method according to claim 13, wherein the recording data of the same or symmetrical sub-areas having different positions within the parcel are stored only once under one address.

15. A method according to claim 13, wherein the recording data of symmetrical sub-areas are transferred before recording into an operation register and from there are discharged for recording in a reciprocal sequence by an electronic control system.

16. Method of reproducing pictures, substantially as hereinbefore described with reference to the accompanying drawings.

17. Apparatus for reproducing pictures, substantially as hereinbefore described with reference to Fig. 7 of the accompanying drawings.

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1355540 COMPLETE SPECIFICATION
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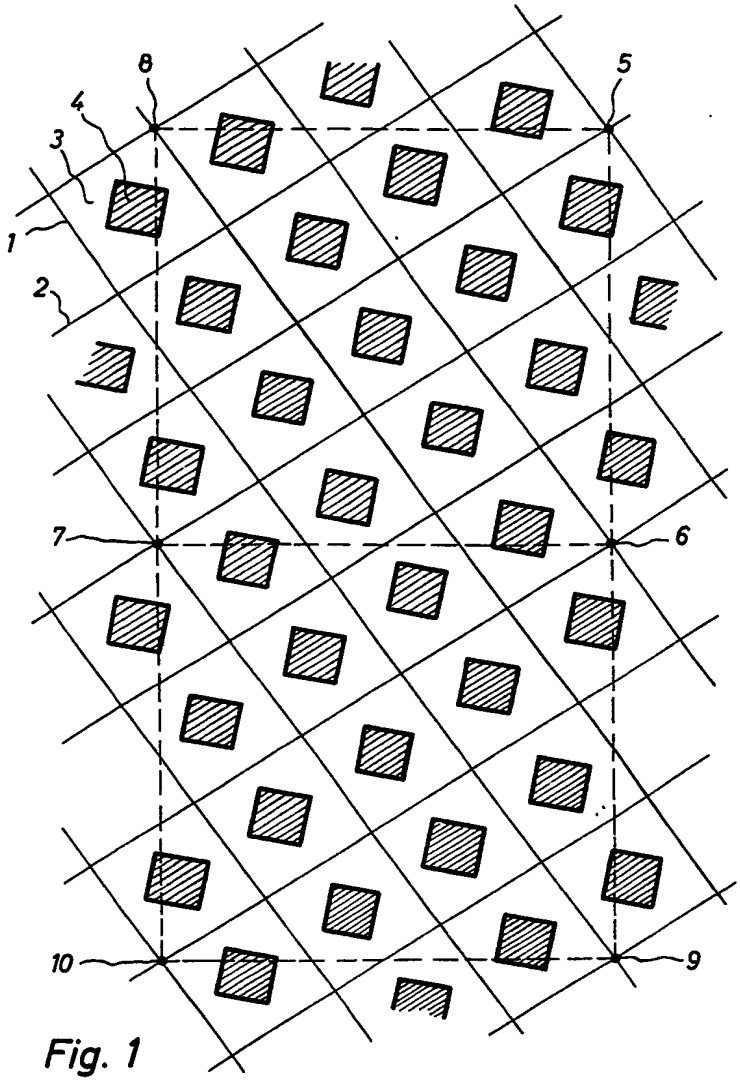

Fig. 1

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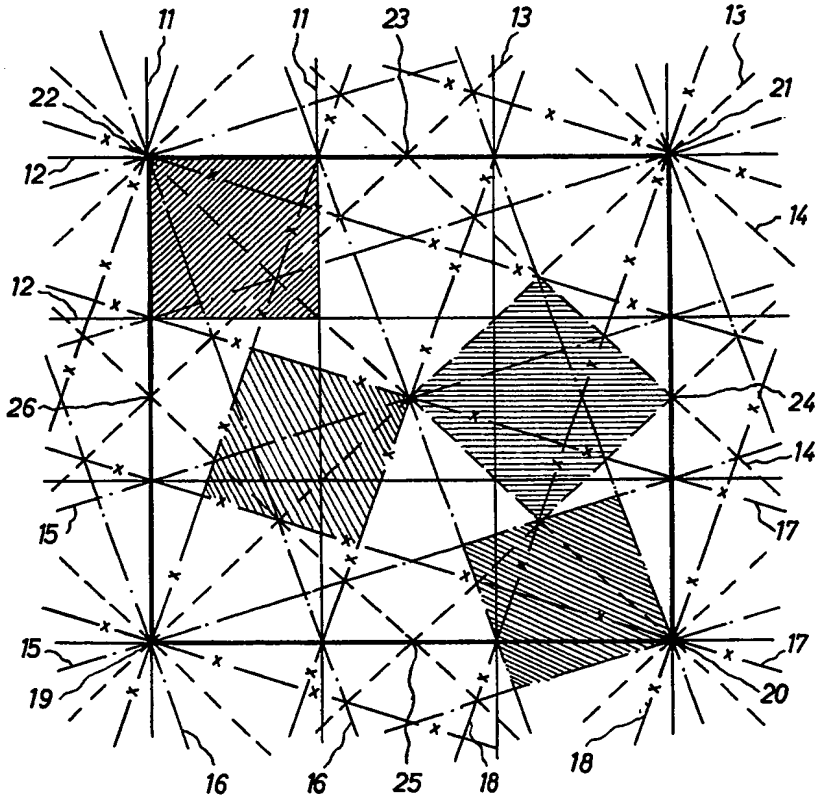

Fig. 2

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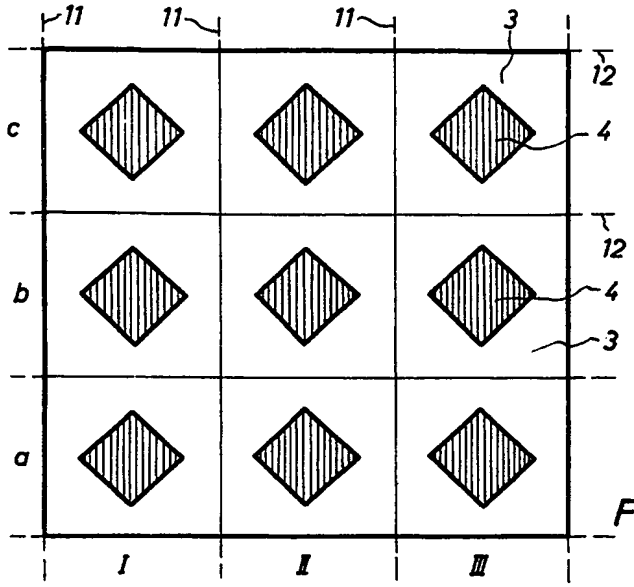

Fig. 3a

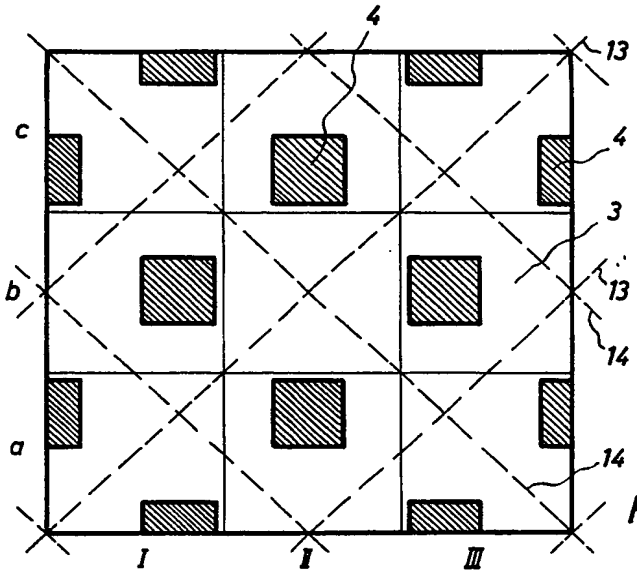

Fig. 3b

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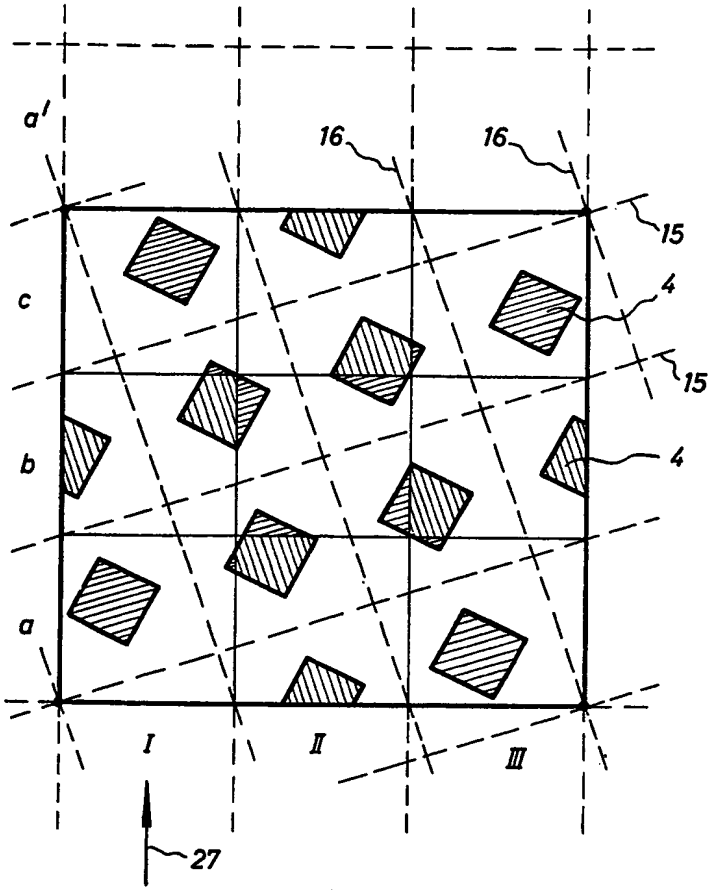

Fig. 3c

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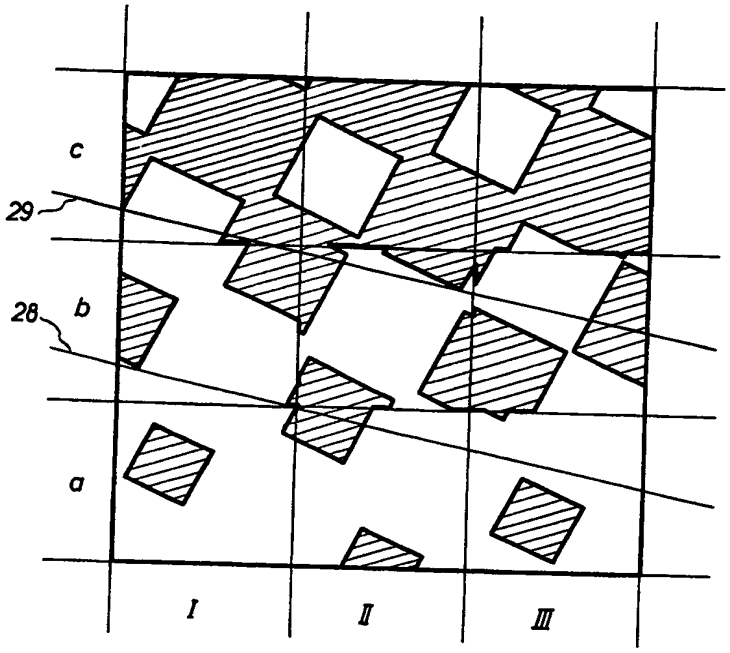

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BNSDOCID: <GB___1355540A_I_>

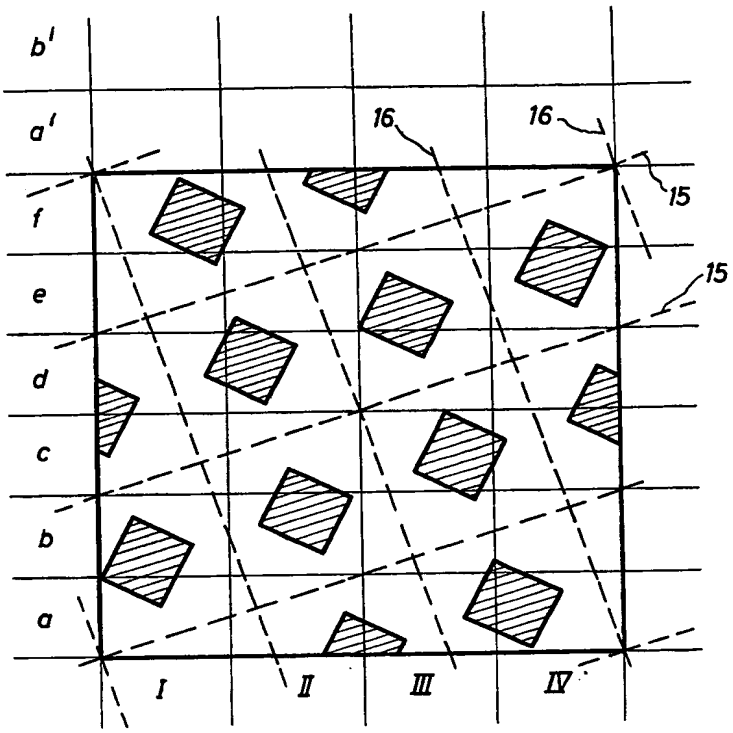

Fig. 5a

BNSDOCID: <GB___1355540A_I_>

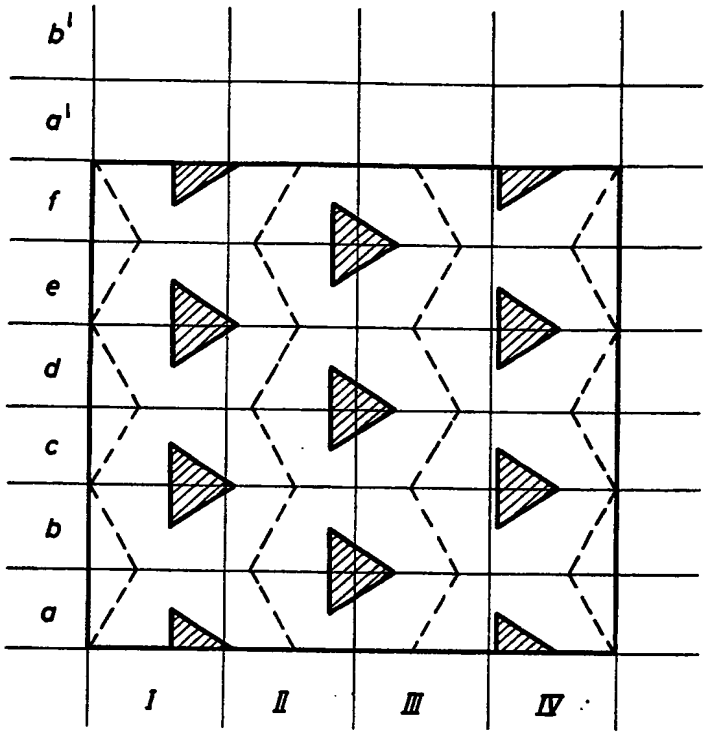

Fig. 5b

BNSDOCID: <GB___1355540A_I_>

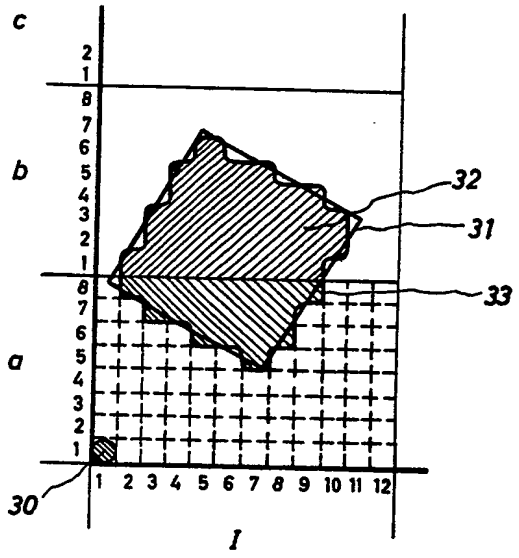

Fig. 6

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1355540 COMPLETE SPECIFICATION
9 SHEETS *This drawing is a reproduction of the Original on a reduced scale*
Sheet 9

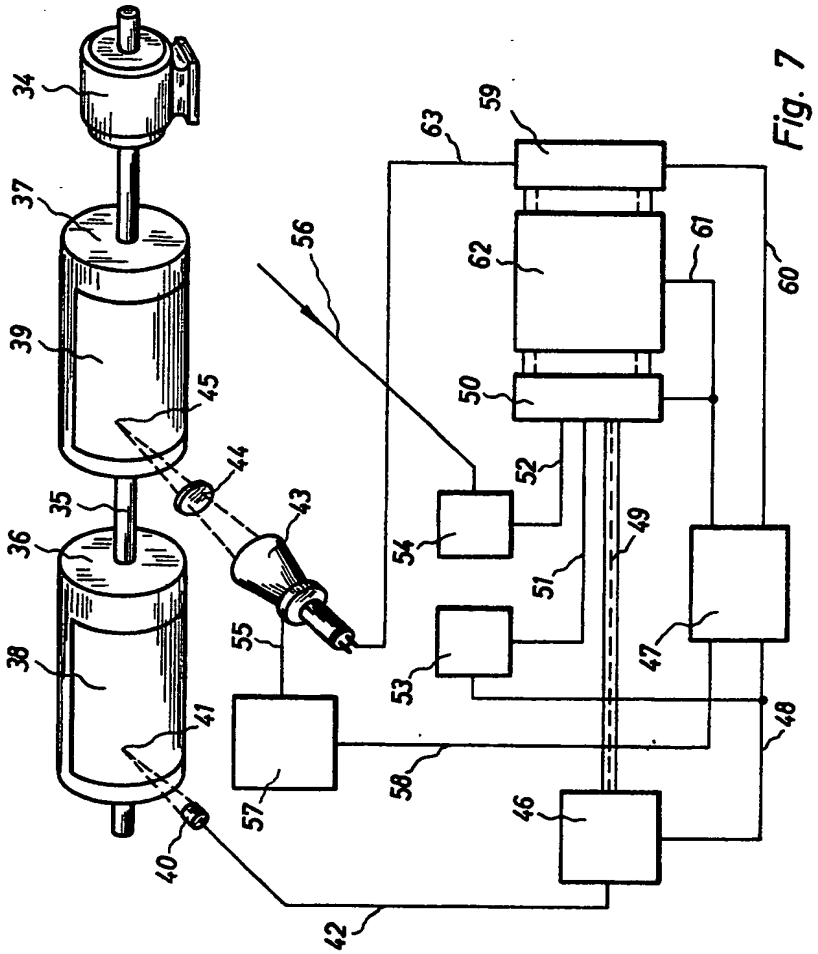

Fig. 7

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